Influence of the Microstructure on the Thermal Properties of Polycrystalline Diamond Films of Micrometer Thickness

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Chemical vapor deposited (CVD) diamond is well known as a promising material for device-adapted solutions for the thermal management problems in electronic systems, because of its high thermal conductivity, its low electrical conductivity, and the possibility of large-area deposition on different substrate materials. Among the most promising approaches are those that integrate diamond layers only a few microns thick directly into semiconductor devices. For the predication and improvement of the performance of these applications, it is essential to have data for the thermal properties of thin diamond layers and their dependence on microstructural properties. However, up to now, only a few experimental investigations have dealt with the thermal properties of diamond on a micrometer scale.

In this work, the correlation between the thermal and microstructural properties of micrometer thick CVD diamond layers deposited on (001) silicon was investigated. The layers investigated span a wide range of structural properties from random small-grained over columnar to highly oriented grain structures. The vertical thermal conduction through the boundaries of these diamond layers with silicon was measured by a pulsed laser-heating method, which has proven to be sensitive to the thermal resistances resulting from both the near-interfacial disorder and the remaining diamond layer [1]. It was observed that the thermal resistance for vertical conduction is strongly influenced, for a given layer thickness, by the grain size and the degree of grain orientation in the direction of growth. In order to investigate the thermal anisotropy of these layers, the lateral thermal diffusivity was measured by the photothermal displacement technique at transient thermal gratings. It was found that the vertical thermal conductivity is an order of magnitude greater than the lateral thermal conductivity for columnar-grained and highly oriented layers about 2 µm thick. For a deeper understanding of the thin film thermal properties measured, microstructural investigations of the interface and grain boundaries of these thin films will be performed using transmission electron microscopy and electron energy loss spectroscopy. Additional insights into the correlation between thermal and structural nonhomogeneities on a micrometer scale are provided by recent photothermal and optical spectroscopy mapping experiments [2].

- [1] H. Verhoeven, H. Reiβ, H.-J. Füβer, and R. Zachai, Appl. Phys. Lett. 69, 1562 (1996).
- [2] H. Verhoeven, J. Hartmann, M. Reichling, W. Müller-Sebert, and R. Zachai, *Diamond and Relat. Mater.* 5, 1012 (1996).